

Overview of the NGNGV Program

**November 7-8, 2000
Embassy Suites Hotel
Dallas, Texas**



NGNGV Program is Sponsored by



U.S. Department of Energy

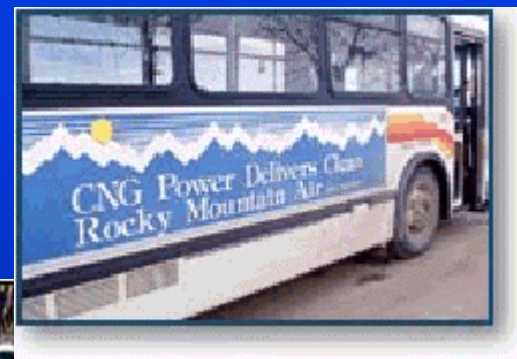
**Office of
Transportation Technologies**



**National Renewable
Energy Laboratory**

Department of Energy: Investing in Clean Air Technologies

- DOE has invested significantly in heavy vehicle technologies in the last ten years
- These technologies have helped make significant incremental advancements toward cleaner, more efficient vehicles
- DOE now wants to take a bold step in developing a new generation of advanced medium and heavy-duty natural gas vehicles



Vision for the Future

Develop one medium-duty (Class 3-6)
CNG Vehicle by 2004



Vision for the Future

Develop one heavy-duty (Class 7-8)
LNG vehicle by 2004





NGNGV Vision and Goals for the Future

**One medium-duty (Class 3-6) CNG vehicle and
one heavy-duty (Class 7-8) LNG vehicle
will be available in 2004 that:**

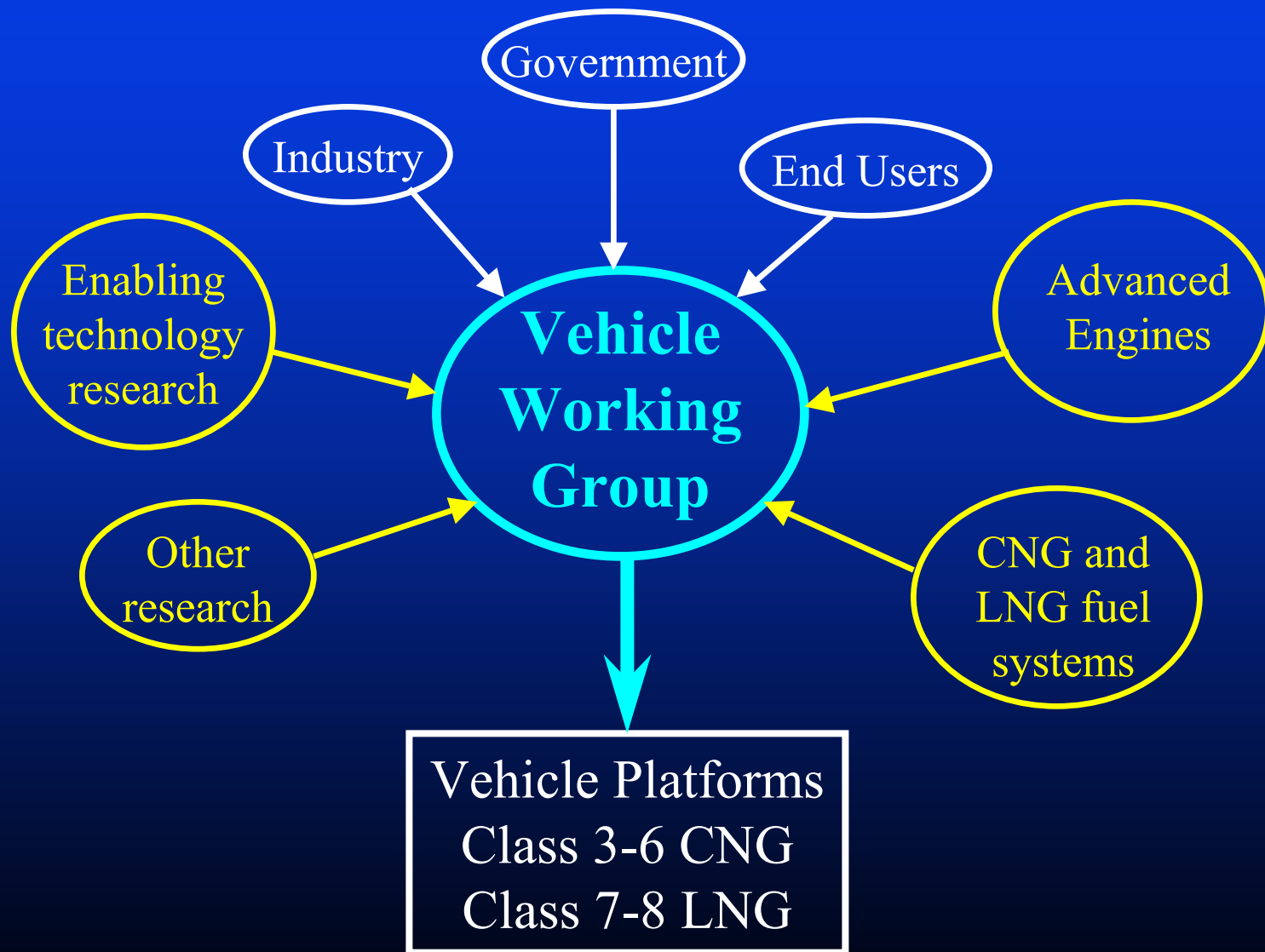
- ✱ Implement advanced DOE natural gas and heavy-vehicle technologies
- ✱ Implement high efficiency engine technology
- ✱ Implement step change in technology over current NG vehicles
- ✱ Have exhaust emission levels below proposed emission standards for 2007
- ✱ Are fully competitive with diesel vehicle counterparts in terms of performance and life-cycle economics
- ✱ **Are commercially viable**



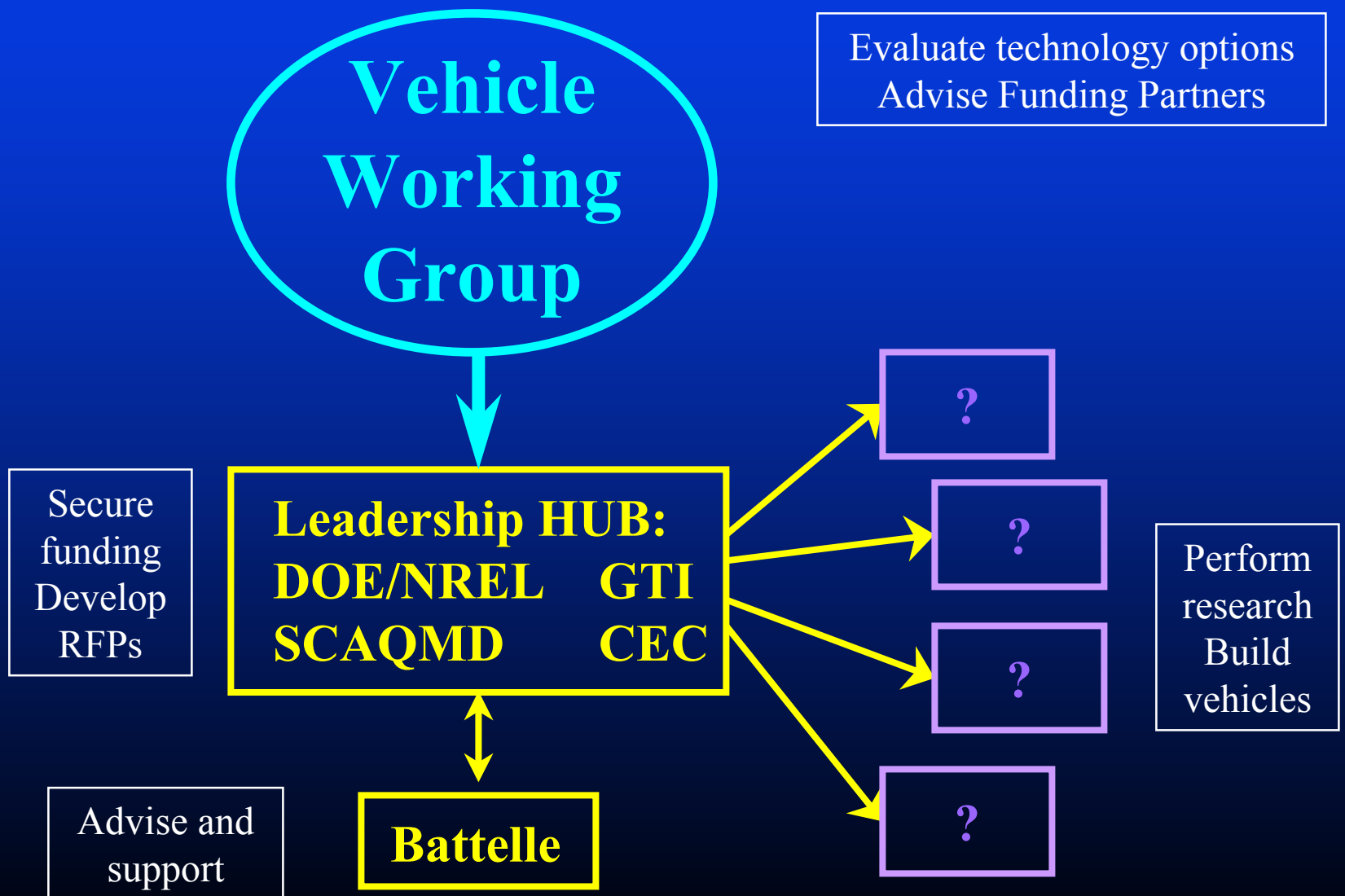
Draft Definition of a Successful Outcome of This Program

- Vehicles
 - Impressive, highly efficient vehicles which outclass diesel in emissions, lifecycle cost and performance
 - Commercial vehicles available by 2004
- Customers
 - Participate in specifications and development process
 - Well informed and desire to purchase vehicles
- Design and development partners
 - Far sighted and committed to vehicle commercial success
 - Partner with customers to develop and deploy vehicles

Program Integration



NGNGV Program Structure





Two Rounds of Research

Round 1
FY2001
Enabling
Technologies

Round 2
FY2002
Prototype
Vehicles



Two Rounds of Research

Round 1
FY2001
Enabling
Technology

Round 1

technology R&D that...

- is close to completion
- could be completed with a relatively short, focused research effort
- could be made commercially viable in the 2004 time frame
- overcomes current barriers to natural gas vehicle introduction

Two Rounds of Research

Round 2

Development of two prototype vehicles to be put in service in on-road development in 2004.

- Class 3-6 CNG Vehicle
- Class 7-8 LNG Vehicle

Round 2
2002
Prototype
Vehicles



Program Strategy for Success

- Commercial success will require
 - an economically attractive vehicle,
 - a broad customer base and
 - a stable fueling and maintenance infrastructure
- Chassis and engine OEMs will want evidence of a market for these vehicles before they invest and support the program
- The vehicles must be built with industry participation and industry support
- Customers must be included in the development process from the very beginning

Program Strategy

- DOE proposes a **three-element strategy** built on active involvement of key stakeholders:
 - 1) **Conduct interactive workshops** to identify most critical vehicle platforms needed
 - 2) Design, develop and evaluate prototype vehicles with the active involvement and support of OEMs and the gas industry through an Ad Hoc Vehicle Working Group
 - 3) **Coordinate enhancement of the fueling and maintenance infrastructure** to ensure successful deployment and market growth



Program Timeline

2000

2001

2002

2003

2004

Prototype Vehicle Design, Development and Evaluation

Establish Vehicle Working Group

Develop design strategy and identify remaining technology obstacles

Define duty cycle and performance specifications

Complete R&D to overcome remaining obstacles

Competitive solicitation for vehicle development

Design and develop prototype vehicles

Baseline Performance Testing

Emissions Testing

Accelerated Reliability Testing

Deployment



Vehicle Development with the assistance of an Ad Hoc Vehicle Working Group

- An Ad Hoc Vehicle Working Group (VWG) can help obtain
 - experienced technical guidance in the design and development process
 - cooperation among diverse stakeholders
 - acceptance of plans by the OEMs and NGV industry
 - industry support and cofunding
 - long-term commitment to vehicle development and marketing

Proposed Program Timeline

FY2000	FY2001	FY2002	FY2003	FY2004
Creating Market Interest and OEM Support				
Stakeholder workshops				
Ongoing industry communications				
Identify first-tier markets and vehicle needs				
Define vehicle applications				
		Solicit pre-production sales		
			Early announcements	
				Rollout

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Accelerated Reliability Testing				
Deployment				

Fueling and Maintenance Infrastructure and Field Support

Evaluate existing infrastructure in first and second tier markets				
Determine vehicle infrastructure requirements				
Develop infrastructure support strategy				
Coordinate infrastructure development				
Train infrastructure staff				



THE key feature of these trucks must be...

Commercial Viability



Creating Market Interest and OEM Support

Pick the right vehicles to develop with input from

- The Vehicle Working Group
- Clean Cities stakeholders
- Key fleet operators

Identify the best “first tier markets” to introduce the new vehicles

Open dialog with key potential customers and maintain the dialog throughout the program.

- Understand and identify their needs for heavy-duty NGVs
- Build market interest and support
- Encourage incorporation of the vehicles into plans for attaining air quality objectives

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<u>Train infrastructure staff</u>				



Fueling and Maintenance Infrastructure and Field Support

Experience has shown that successful deployment and subsequent market growth requires

- Stable and reliable fueling infrastructure
- highly responsive maintenance and field support programs

For first vehicles we will coordinate enhancements of fueling and maintenance infrastructure including

- Evaluating existing infrastructure and determining needs
- Developing an infrastructure support strategy
- Coordinating enhancement activities
- Training the infrastructure and support personnel

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Fueling and Maintenance Infrastructure and Field Support

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Stakeholder Workshops and Meetings

- Clean Cities Regional Conference El Paso March 29-30
 - One one-hour workshop
- NGNGV Vehicle Working Group Workshop, Chicago, May 2-3
 - 1 day workshop
- Clean Cities National Conference, San Diego, May 9-11
 - Two one-hour workshops
- Waste Management Meeting, Las Vegas, September 19, 2000
 - One-on-one customer meeting
- New York Area Workshop, Long Island, September 29, 2000
 - ½ day workshop



Stakeholder Workshop Goals

- Give participants a clear understanding of the NGNGV Program
- Provide an overview of existing applicable DOE, GRI, SCAQMD, and CEC research
- Obtain input on the technologies and vehicles that should be developed in the program:
 - Vehicle types and markets
 - Natural gas engine technologies
 - Vehicle fuel system and storage technologies
 - Body and chassis technologies
- Gain early interest and support for the program

NGNGV Vehicle Working Group Meeting May 2 and 3, 2000 in Chicago

Over 40 Participants....

- Original Equipment Manufacturers and Vehicle Packagers
 - Crane Carrier Company
 - Cummins Engine Company
 - FAB Industries, LLC
 - Ford Motor Company
 - Freightliner Corporation
 - John Deere Power Systems Group
 - Mack Trucks Inc.
 - Orion Bus Industries
 - PACCAR Technical Center





NGNGV Vehicle Working Group Meeting May 2 and 3, 2000 in Chicago

- Fleet operators
 - United Parcel Service
- Industry/ Trade Associations
 - American Trucking Associations
 - Natural Gas Vehicle Coalition
- Funding Partners
 - California Energy Commission
 - GRI
 - South Coast Air Quality Management District
 - U.S. Department of Energy
- Utilities and Fuel Distributors
 - KeySpan Energy
 - Pacific Gas and Electric Company
 - Southern California Gas Company
- National Laboratories and Research Groups
 - Argonne National Laboratory
 - Brookhaven National Laboratory
 - Idaho National Engineering and Environment Laboratory
 - National Renewable Energy Laboratory
 - Oak Ridge National Laboratory

Workshop Participants (continued)

- Equipment Suppliers
 - CHART-MVE
 - Lincoln Composites
 - Pressed Steel Tank
- Industry Research, Consulting and University
 - Arthur D. Little, Inc
 - ASG Renaissance
 - Battelle
 - BusPlan
 - Institute of Gas Technology
 - Southwest Research Institute
 - The Research Partnership
 - West Virginia University





Input from the Vehicle Working Group

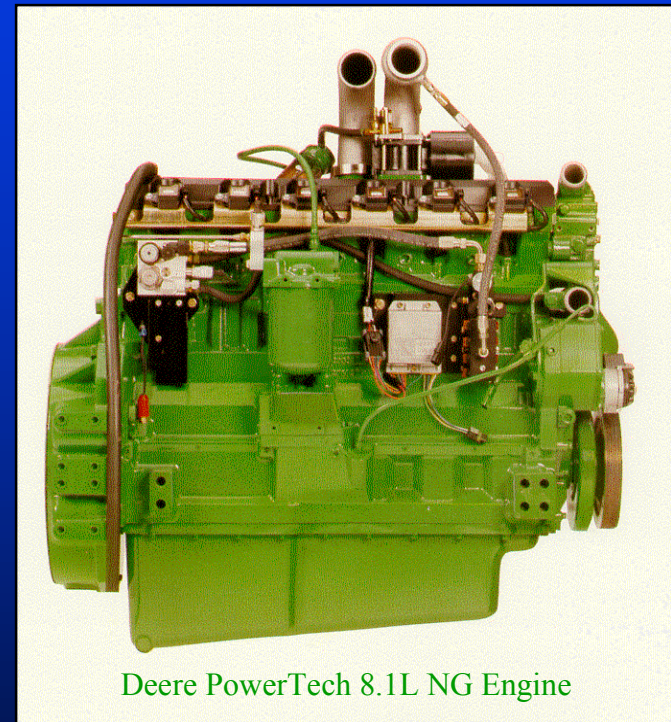
- Participants divided into four groups to provide recommendations on:
 - Vehicle types and markets
 - Natural gas engine technologies
 - Vehicle fuel system and storage technologies
 - Body and chassis technologies
- Groups rotated such that everyone had input to each topic
- Recommendations were then organized and categorized by participants
- All participants voted to identify most critical issues and technologies



Summary of DOE Vehicle Technologies

Potential Engine Technologies

- Advanced Engine Controls
- Port Fuel Injection with Skipfire
- Advanced Turbocharger Configurations
- Advanced Piston and Camshaft Designs
- Knock Detection and Control
- Upgraded power
- Low Profile Cooling Systems
- High pressure fuel injection
- Exhaust aftertreatment



Deere PowerTech 8.1L NG Engine

Potential Fuel Storage and Delivery Technologies

- "Smart" Onboard Cylinder Monitoring
- Conformable Fuel Storage
- Adsorption Fuel Storage
- Damage Indicator Coatings
- Lower weight, lower cost fuel tanks
- Reduced LNG Boiloff
- Improved efficiency and integrated fuel system design



Chassis Mount NGV tanks.



Potential non-engine Chassis Technologies


- Advanced technology brakes
- Modified Frame Design
- High Strength, Weight Reducing Materials
- Advanced, Low friction Geartrain
- Low resistance tires
- Low power auxiliaries
- Anti-idling technology
- Fuel System Packaging



Potential Body and Other Technologies

- Advanced aerodynamic bodies with reduced drag,
- Reduced rolling friction, and
- Reduced parasitic power losses.
- Advanced, Low Friction Materials
- Integrated Manufacturing
- Driver assistance technologies
 - Heads up display
 - Forward and backward seeing radar





Vehicle Working Group and Stakeholder Meetings Summary of Results and Recommendations



Vehicle Types and Markets

Medium-Duty CNG Vehicles

- Most needed vehicles
 - Delivery vehicles (54)
 - Pickup & delivery trucks, Step vans, Strip chassis and Cab chassis
 - Paratransit & Small bus (35)
 - 28-32 Passenger school bus, Paratransit, Hotel/rental car shuttle, Cutaway
- Potential customers
 - Mail and package delivery companies
 - Airport and hotel shuttles
 - Beverage delivery
 - Local delivery
 - School districts



Vehicle Types and Markets

Heavy-Duty LNG Vehicles

- Most needed vehicles
 - In-city route trucks (60)
 - Short-haul day cab for regional delivery
 - Class 7-8 refuse truck for long haul transfer
 - Over-the-road tractor (29)
- Potential customers
 - Short-haul grocery/food goods transport
 - Long-haul mail/package transport
 - Waste & trash haulers



What will be the Key Performance Specifications of these Vehicles?

- Cost (50)
 - Improved economy (low fuel use at idle), Low cost of ownership, Durability
- Performance (31)
 - Diesel-like torque (gradeability), Part-load efficiency related to vocation, Driveability, Medium-duty should have gasoline based engine, Heavy-duty should have diesel based engine
- Maintenance (17)
 - Low maintenance, Safety and cost, Ease of Fueling, Reliability



What incentives will customers need to adopt these vehicles?

- **Low life cycle cost (38)**
 - **Competitive initial cost, Low operating cost to offset initial cost, Large, long-term fuel price differential**
- **Tax credits (31)**
 - **Tax credit on fuel used, Reduced local and state registration and sales taxes, SIP Incentives**
- **Infrastructure (20)**
 - **Friendly refueling infrastructure, Infrastructure cofunding, Improved safety during fueling and operation**
- **Emission credits (15)**
 - **Mobile emission credits, NOx credits**
- **Customer satisfaction (6)**
 - **Noise reduction, Extended warranty, Access to service/parts over the life of the vehicle**
- **Mandates (2)**
 - **Fleet rule, EPACT credits, Punishment avoidance (lawsuits)**



NG Engine Technologies

What engine performance features will be important to customers of natural gas vehicles?

- Lower cost - lower operating cost than diesel, equal fuel economy, longer service intervals, lower maintenance cost (31)
- Driveability - Power and torque equal to or better than diesel (16)
- Emissions below 0.5 g/b hp-hr NO_x and 0.01 g/b hp-hr PM (11)



NG Engine Technologies

What Engine Technologies should be Incorporated into Leading Edge NG Vehicles?

- Direct Injection Natural Gas (DING) (21)
- Ultra-lean burn Spark Ignition Natural Gas (SING) (18)
- Rich burn with EGR (Stoichiometric NG combustion for low emissions with after treatment) (17)

Aftertreatment should be investigated including

- a lean NO_x catalyst (34)
- protection of catalyst from contaminants (28)
- total hydrocarbon reduction (29)



Fuel System and Storage Technologies

What Fuel System & Storage Features will be Important to CNG Vehicles in 2004?

- Lower cost containers (21)
- Real-time on-board integrity monitoring of fuel cylinders (23)
- Smart vehicle/station fueling and fuel system design to ensure full fill (16)
- Accurate metering (11)
- Low pressure absorption systems (6)



Fuel System and Storage Technologies

What Fuel System & Storage Features will be Important to LNG Vehicles in 2004?

- Low cost tanks (14)
- Accurate On-board Fuel Gauge (11)
- Integrated multi-tank fuel System (14)
- Venting management for reduced boiloff (15)
- Maximized energy density storage system (18)
- Standardized, user-friendly fueling (21)



Body & Chassis Design

Medium-duty CNG

- Design body to accommodate large diameter tanks and large aftertreatment devices (23)
- Vehicle should look like “conventional” except for NG fuel system (12)
- Utilize voids in body to fit fuel storage
- Use structural integrity of storage tank to minimize/reduce weight of chassis/body (frames are designed to flex) (9)
- Ask the customer (13)
- Maintenance cost cannot exceed diesel(9)
- Capable of 5 minute fill (11)
- Cut away chassis shuttle vehicle
- Continuous Variable Transmissions to make up for fuel economy (11)



Highlights: Body & Chassis Design

Heavy duty LNG


- Design to accommodate fuel tanks (32)
- Encourage SAE to adopt Body & Chassis features that accommodate LNG fuel tanks (16)
- Vehicles should look the same as conventional vehicles (14)
- Anti idling (19)
- Chassis OEM willing to build truck with NG engine (15)
- Advanced cooling system components (13)
- Driveline optimization (12)
- Advanced LNG Tank protection (11)
- NG auxiliary power unit (9)



Clean Cities Regional Conference

El Paso, March 29&30, 2000

- Approx 25 participants
- Focus on Vehicle Types and Markets
- Medium-Duty CNG Vehicle
 - Paratransit and CutAway for Shuttles
 - Package and General Purpose Delivery
- Heavy-duty LNG Vehicle
 - Refuse Haulers
 - Class 8 Day Haul Tractor for Local Delivery



Clean Cities National Conference

San Diego, May 9 & 11, 2000

- Two Workshops totaling approx. 100 participants
- Focus on Vehicle Types and Markets
- Medium-Duty CNG Vehicle
 - Paratransit and CutAway for Shuttles (11)
 - Package and General Purpose Delivery (7)
 - School Bus (4)
 - Refuse (2)
 - Maintenance (1)
- Heavy-duty LNG Vehicle
 - Refuse Haulers (8)
 - Class 8 Day Haul Tractor for Local Delivery (3)
 - Heavy-duty dump truck (2)
 - Bus (1)



New York Area Workshop

Long Island, Sept 29, 2000

- Approx 40 participants including fleet operators and government representatives
- Focus on Vehicle Types and Markets
- Medium-Duty CNG Vehicle
 - Package and General Purpose Delivery (4)
 - Paratransit and CutAway for Shuttles (1)
- Heavy-duty Vehicle
 - LNG cannot travel through tunnels and is not used in NY city
 - Class 8 Day Haul Tractor for Local Delivery (5)
 - Refuse Haulers (3)
 - Heavy-duty dump truck (1)